Warm water volume changes and transports in the tropical Pacific during the 1997–1998 El Niño

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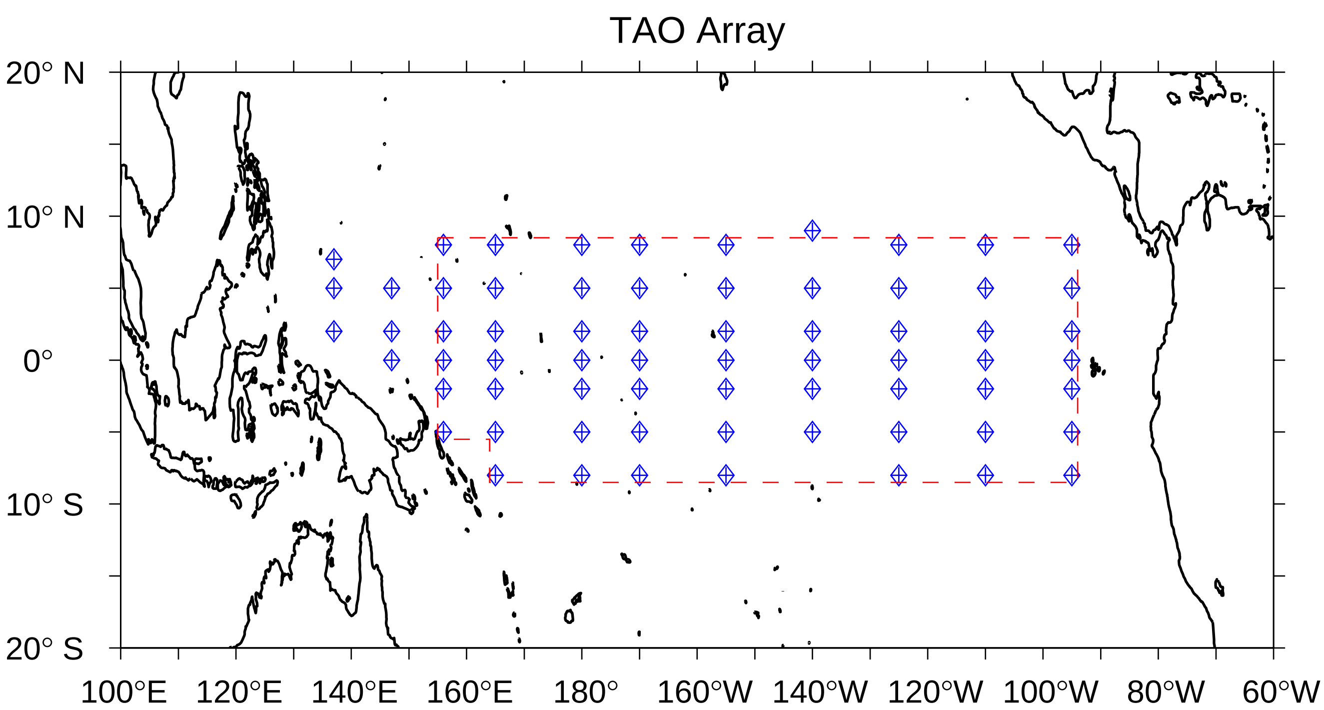

Basic Premise

- The build up and decline of warm water volume in the equatorial Pacific is directly related to the timing of El Niño events.

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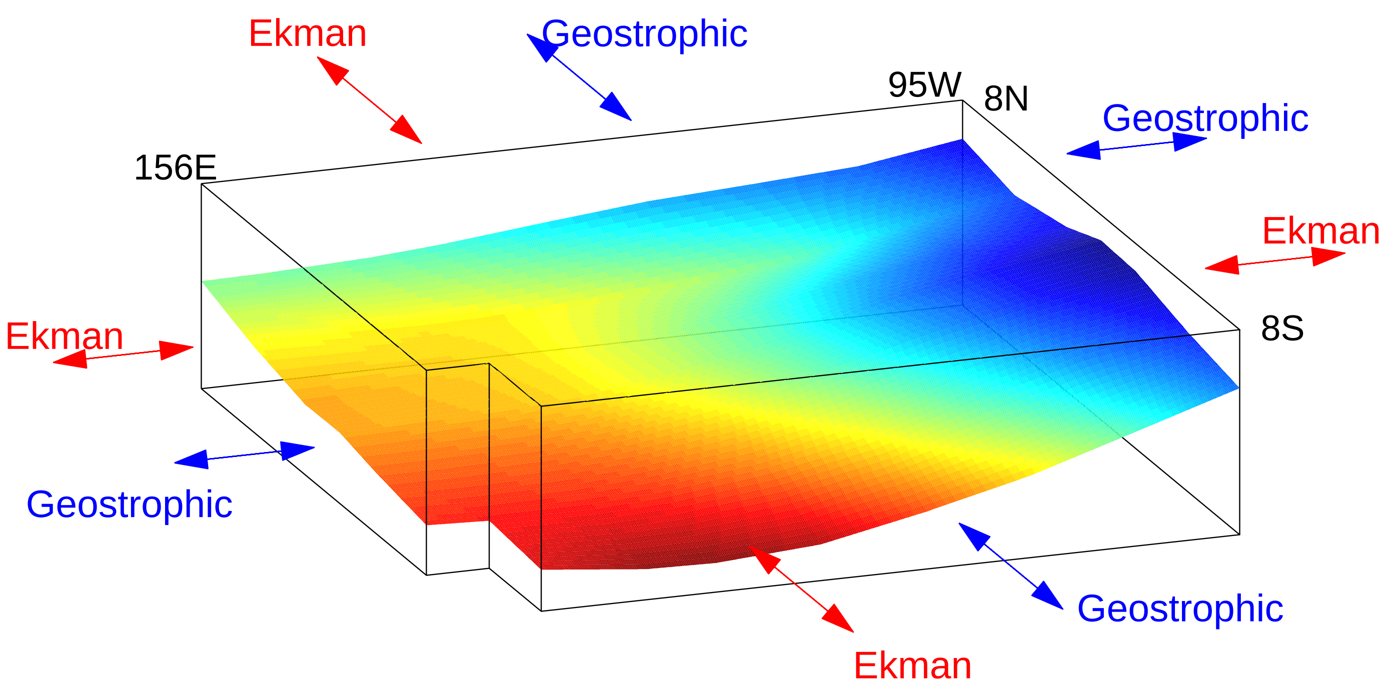
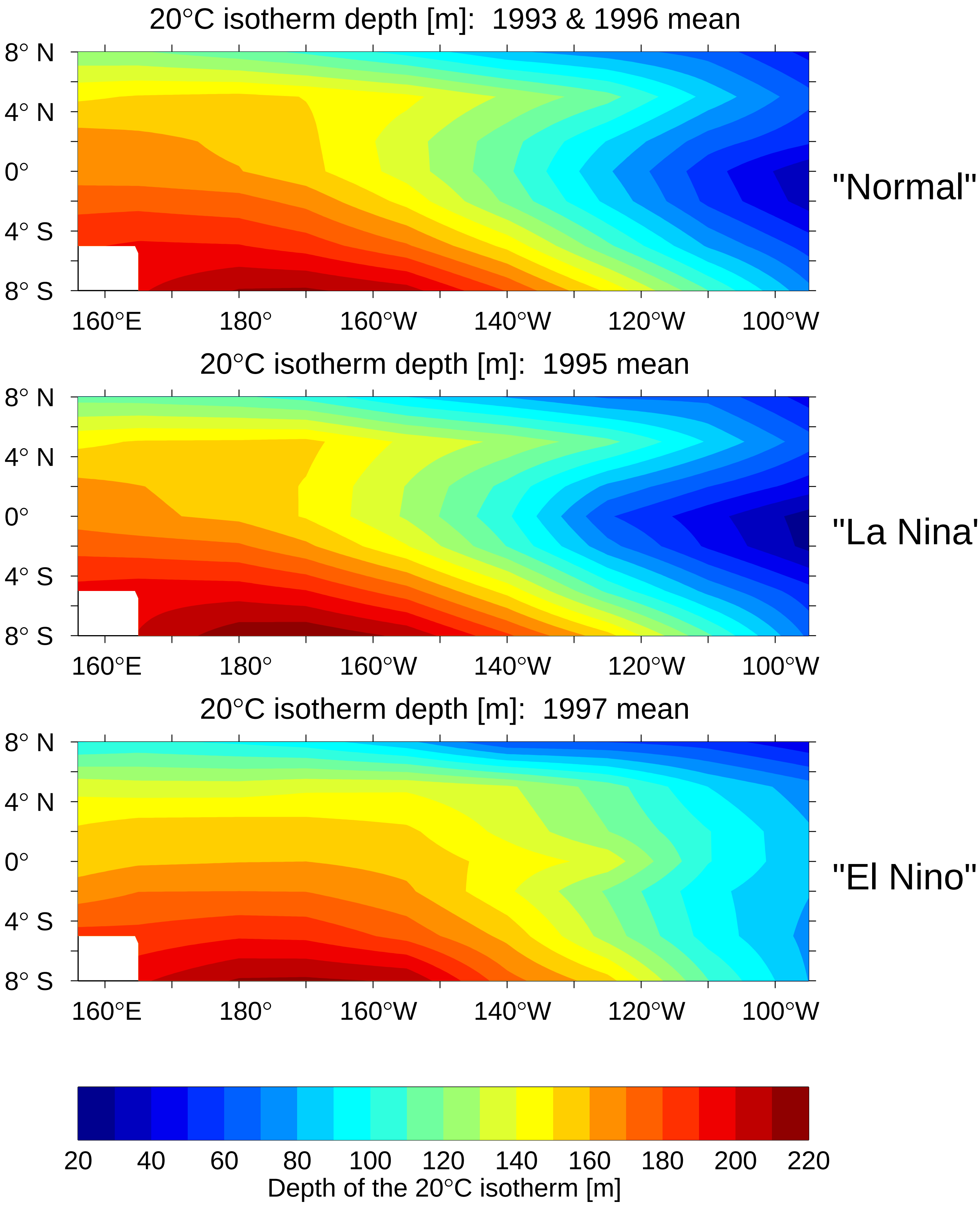
Specific objectives

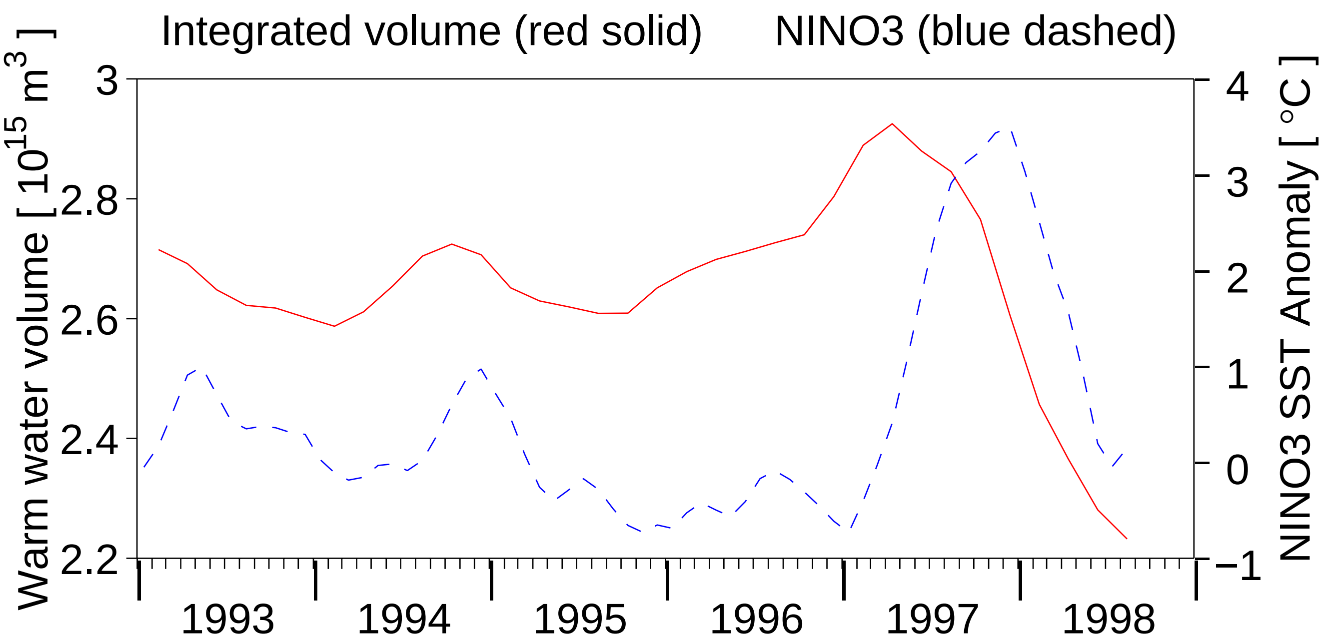
- To quantify the "flushing" of warm water to higher latitudes during the El Niño.
- To quantify the accumulation of warm water between the end of one El Niño and the beginning of the next.
- To quantify the lead time between the peak in the warm water volume and the peak in the SST.
- To compare the 1994 and 1997 El Niño signals and quantify the differences.

Advantages of this Study

- More observations have been made during this El Niño than during any previous El Niño event.
- This El Niño event is one of the largest ever observed, resulting in a favorable signal–to–noise ratio.




20°C isotherm depth [m]: 1993 & 1996 mean
"Normal"
20°C isotherm depth [m]: 1995 mean
"La Nina"
20°C isotherm depth [m]: 1997 mean
"El Nino"
8° N
4° N
0°
4° S
8° S
160°E
180°
160°W
140°W
120°W
100°W
20
40
60
80
100
120
140
160
180
200
220
Depth of the 20°C isotherm [m]



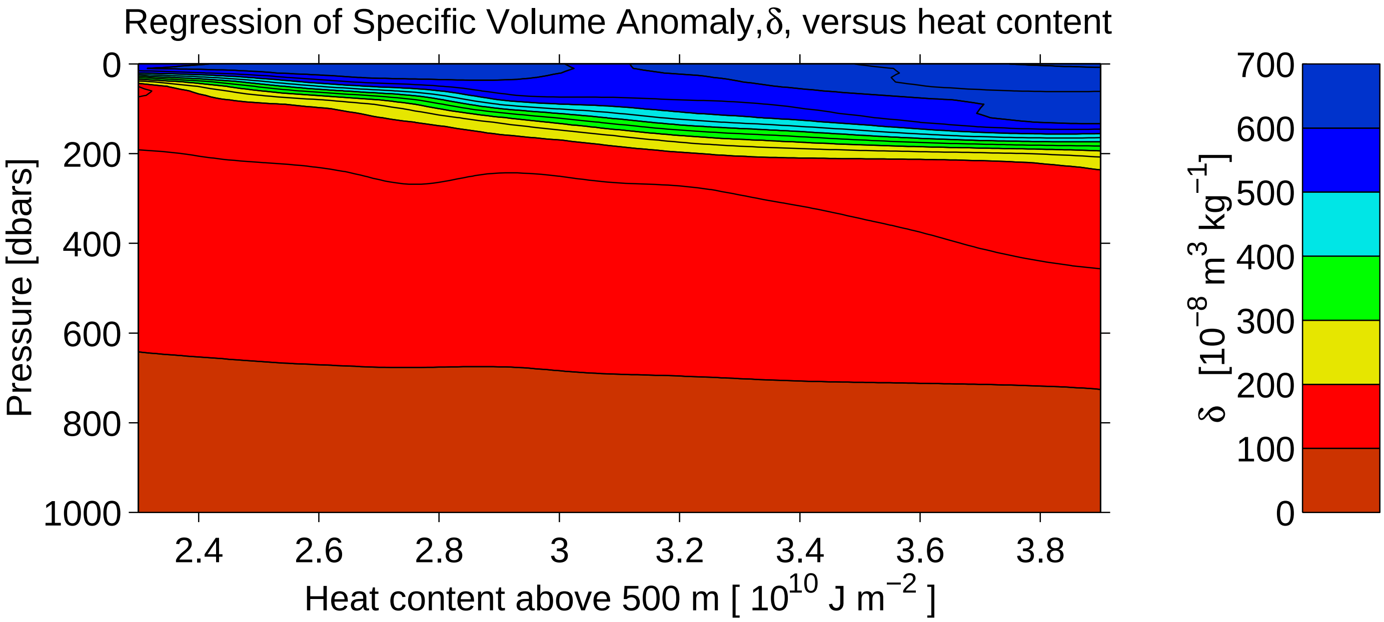
- Warm water volume decreases from Jan. 1993 until Feb. 1994.

- Volume increases from Feb. 1994 until Oct. 1994, this is the buildup prior to the 1994 El Niño.

- Volume decreases from Oct. 1994 until Oct. 1995, this period includes the 1994 El Niño and the beginning of the 1995 La Niña.

- Volume increases from Oct. 1995 until Apr. 1997, this is the buildup prior to the 1997 El Niño.

- Volume decreases from Apr. 1997 until Sep. 1998, this period includes the 1997 El Niño and the beginning of the 1998 La Niña.



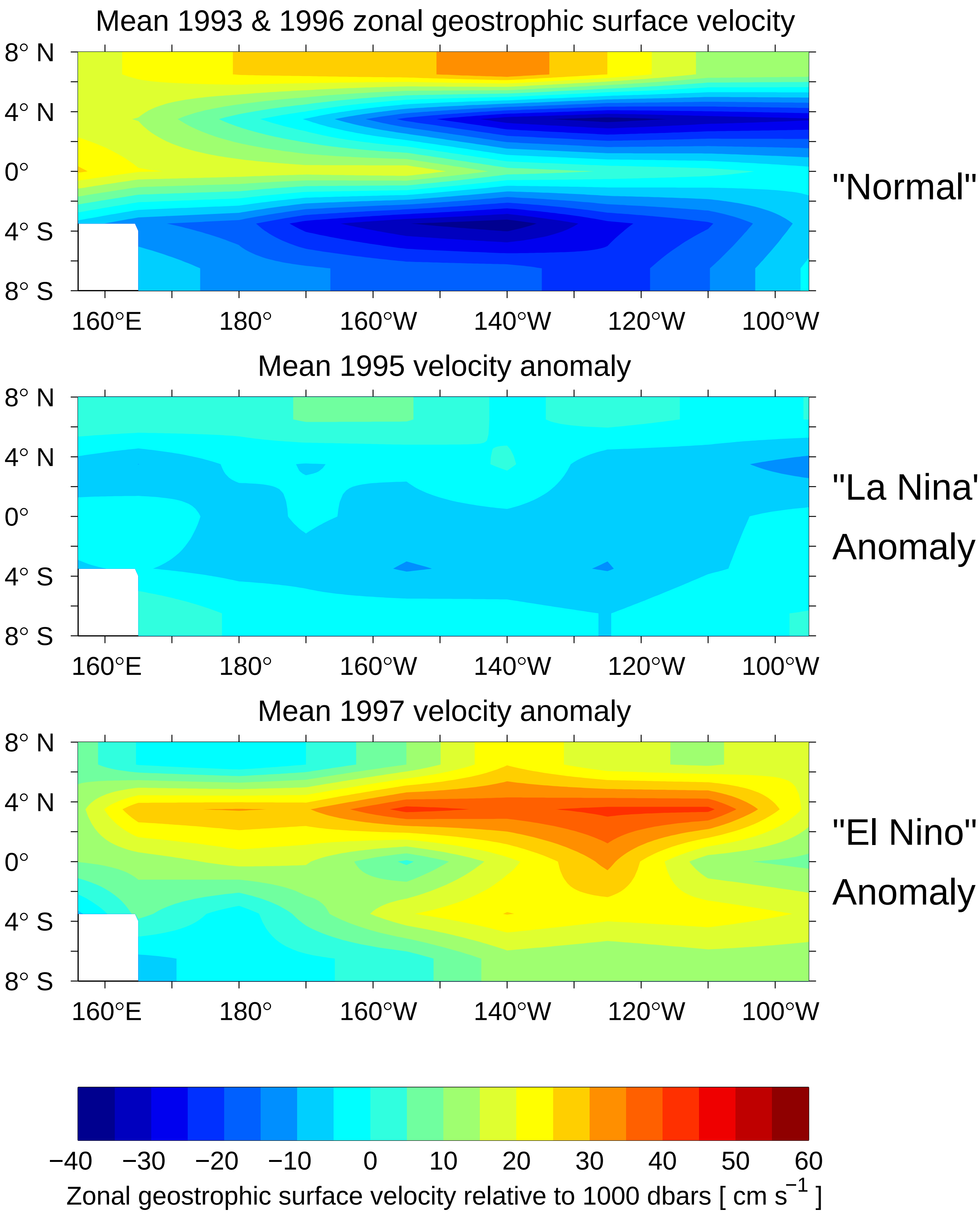
Determining velocity from TAO temperature measurements

• Regress specific volume anomaly against heat content integrated above 500 dbar using historical hydrography (see above figure). [Meinen and Watts, submitted to JGR, 1998]

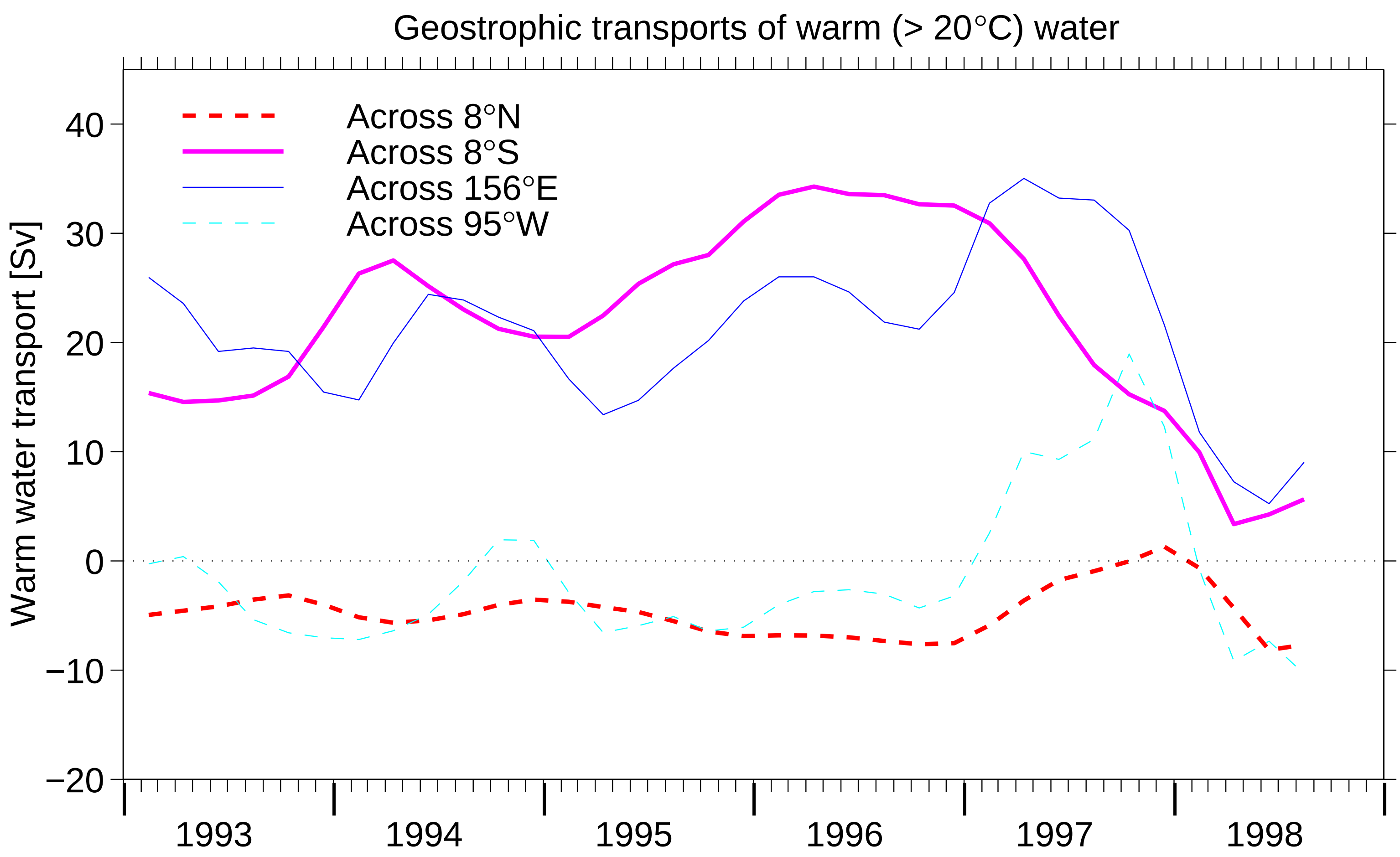
• Use timeseries of heat content from TAO buoys along with regression to give profile of specific volume anomaly at each mooring for each time step.

• Integrate profiles of specific volume anomaly to give geopotential height anomaly.

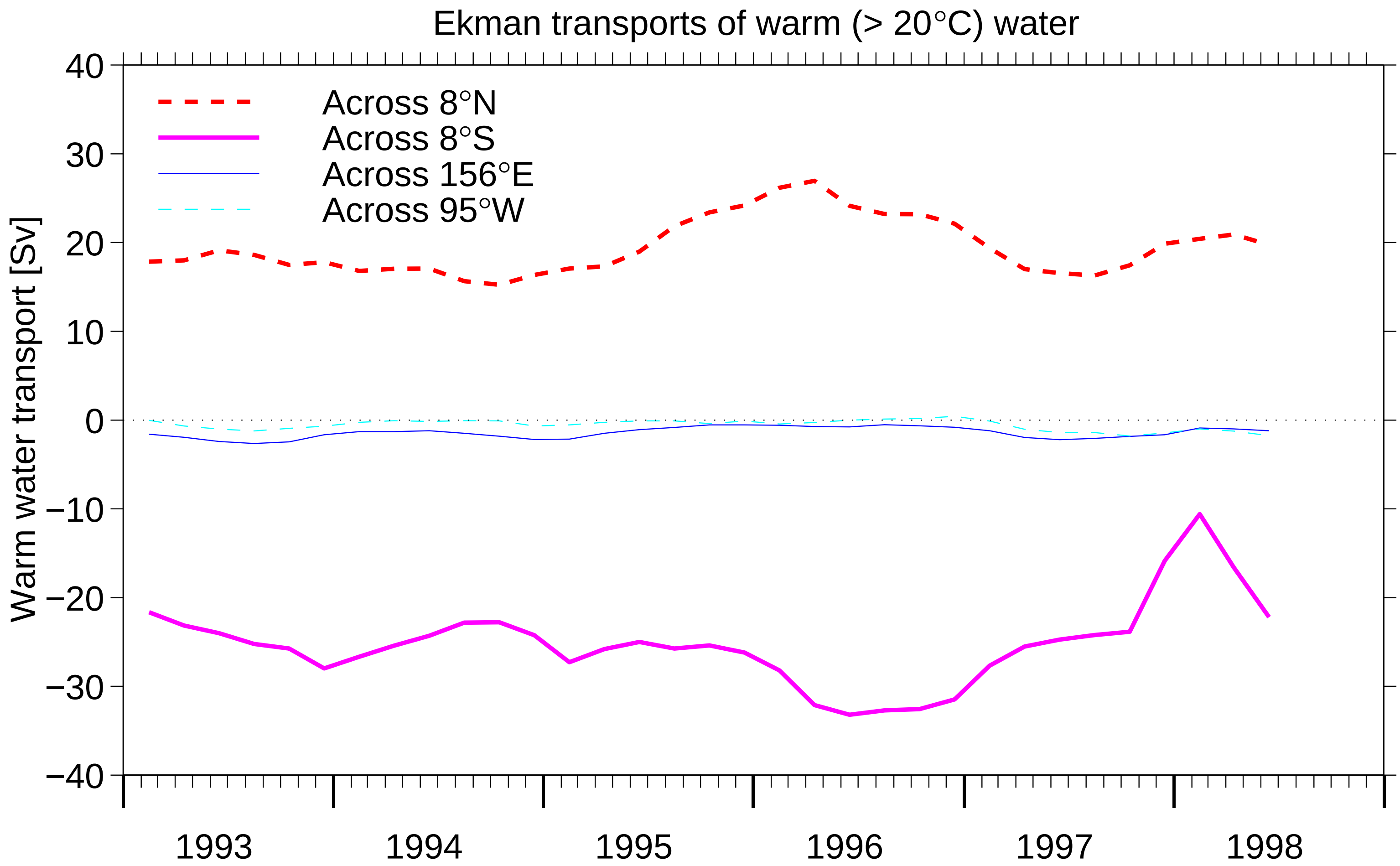
• Use the dynamic method to determine profiles of geostrophic velocity relative to 1000 dbars.



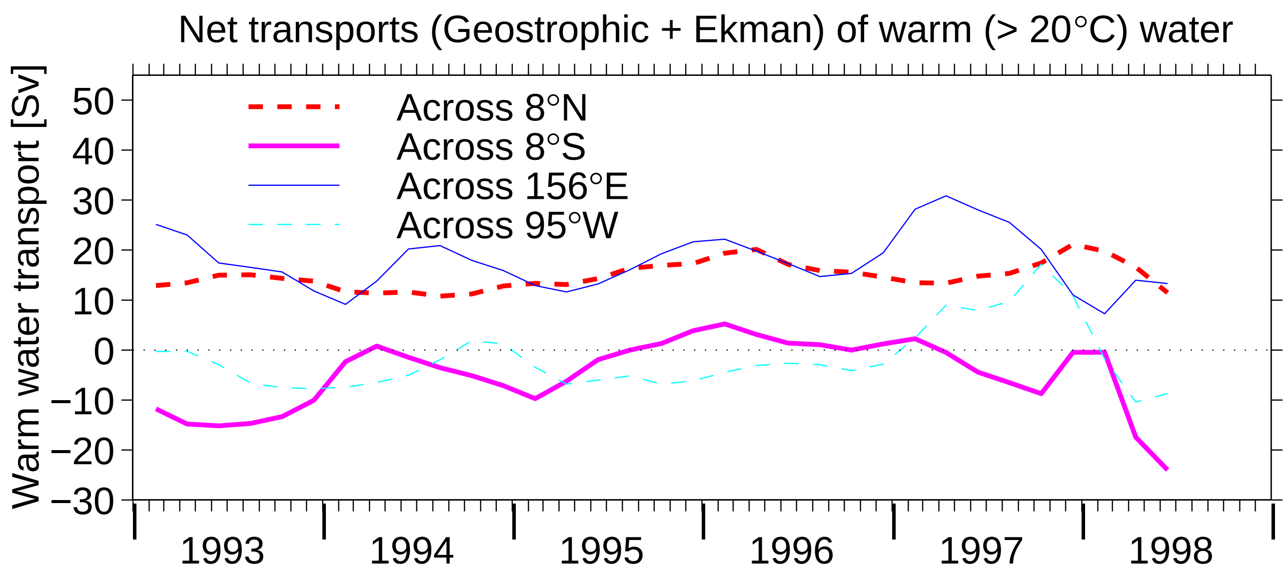
Mean 1993 & 1996 zonal geostrophic surface velocity
8° N
4° N
0°
4° S
8° S
160°E
180°
160°W
140°W
120°W
100°W
"Normal"
Mean 1995 velocity anomaly
"La Nina"
Anomaly
Mean 1997 velocity anomaly
"El Nino"
Anomaly
−40
−30
−20
−10
0
10
20
30
40
50
60
Zonal geostrophic surface velocity relative to 1000 dbars [cm s−1]

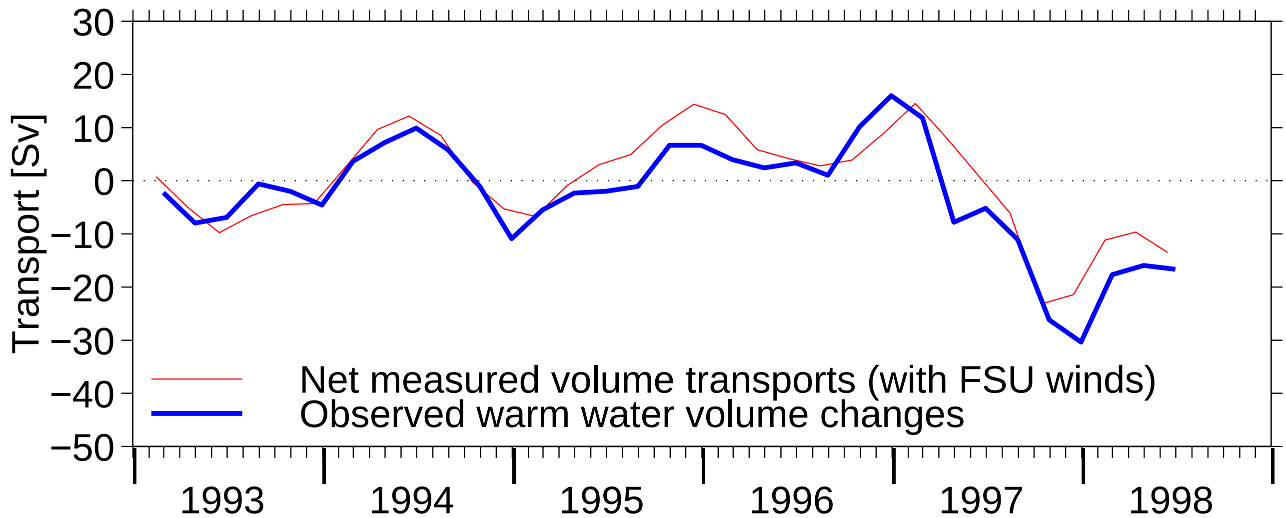


Geostrophic transports of warm (> 20°C) water
Across 8°N
Across 8°S
Across 156°E
Across 95°W
Warm water transport [Sv]
40
30
20
10
0
−10
−20
1993
1994
1995
1996
1997
1998



Ekman transports of warm (> 20°C) water
Across 8°N
Across 8°S
Across 156°E
Across 95°W
Warm water transport [Sv]
40
30
20
10
0
−10
−20
−30
−40
1993
1994
1995
1996
1997
1998





- Correlation coefficient $r = 0.90$
  Mean difference $= -2.5$ Sv
  RMS difference $= 5.1$ Sv

Conclusions

• The volume of warm water showed a significant increase between the 1995 La Niña and the 1997 El Niño, consistent with the model results of Cane et al. and others.

• The peak in warm water volume preceded the peak in sea–surface temperature (integrated over the same region) by 6 months (Apr. 1997 vs. Oct. 1997).

• The loss of warm water during the 1997 El Niño was about 6 times larger than the loss during the 1994 El Niño.

• During the 1997 El Niño the region bounded by 156°E-95°W, 8°S-8°N lost about 28% of its warm water volume and about 31% of its heat content, confirming that one of the effects of El Niño is to transport considerable quantities of heat from the equator towards the poles.

Future work

• Extend the calculation to the eastern boundary and also westward up to the western boundary currents using TOPEX altimetry and XBT data.

• Complete a heat budget calculation for the same region.

• Determine the meridional extent of the El Niño warm water transports using TOPEX and other data sources.